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ANTHROPOLOGY IN CENTRAL AFRICA

A paper by

MAX GLUCKMAN, M.A., D.Phil.,

*Professor of Social Anthropology, University of
Manchester, read to the Commonwealth Section
of the Society on Thursday, 3rd March, 1955,
with I. Schapera, M.A., D.Sc., Professor
of Anthropology, University of London,
in the Chair*

THE CHAIRMAN: Coming here this afternoon I was reminded by Professor Gluckman that it is just 25 years, almost to the day, since I took up a temporary teaching appointment at Johannesburg and found him amongst my pupils there. At that time the only book worth reading on the anthropology of Central Africa was Smith and Dale's *The Ilala-speaking Peoples of Northern Rhodesia*. Since then the literature on Central African ethnography has become one of the best for the whole continent. This development is due very largely to the work of the Rhodes-Livingstone Institute, with which Professor Gluckman was associated for several years as Director, and in which he has continued to take an active interest ever since. He will now tell you the story of the remarkable progress in which he himself was so much concerned.

The following paper, which was illustrated with a map, was then read:

THE PAPER

British Central Africa, like most of the other present political states of Africa, is a region demarcated by European actions during the last century. It comprises three territories occupied in different ways by British authorities and settlers, and thus separated from territories occupied by Portuguese to the east and west, Belgians to the north, Germans to the north-east and south-west, and Boers

to the south. These three territories—Southern Rhodesia, Northern Rhodesia and Nyasaland—were federated only in 1953. Within the borders of the territories are contained many different geographical regions, and they are inhabited by African peoples of different cultural origin. They have different histories of colonization. Nevertheless, it is convenient to take the three territories as a unit in examining anthropological research in Central Africa as a whole. Since 1938 more research in Central Africa has been carried out by the Rhodes-Livingstone Institute, which serves these territories, than by other workers in the neighbouring states. As far as research is concerned, during the last 15 years there has been unity of purpose and problem in British Central Africa.



Most people who read about Central Africa before the British occupation do so in the books of the great missionary writers such as David Livingstone, Robert Moffat and François Coillard, or of administrators such as Sir Harry Johnston. The general picture they give is of a region torn by savage warfare and by the raids of the Ndebele (Matabele) in the south and the Ngoni (Mazitu) in the north, and ravaged by slave-traders, Portuguese, Arab and African. The tribal raiders came from several directions and attacked both already established

African states and congeries of small tribes without highly organized governments. The slavers, armed with muskets, in general raided the weaker groups and traded with the stronger ones, though they were prepared on occasion to meet nations as strong as the Bemba in battle.

It was characteristic of that period that all the African societies of the region were basically cultivators with hoes. Some of them were able to add to their food-supply by herding cattle and small stock where grazing was present and tsetse fly absent, by fishing in the numerous rivers and lakes, and by hunting in the woodlands. Many of the tribes smelted and worked iron into hoes, axes, adzes, spears and knives. They all made string from bark and roots, built their houses of wood and mud or grass, carved dugouts and utensils from wood, and moulded pots from clay. Barkcloth and skins were the common native wear, though there was some spinning and weaving of kidney cotton.

The agricultural systems (Allan, 1949; Trapnell) of the region mostly involved wide shifting, but they varied in complexity. The Serenje Lala practised the simplest form of the ash-planting or *citimene* system (Peters, 1950): they felled a large area of woodland, piled the branches for burning in numerous small circles, and planted millet in the ash seed-bed, which they used only for a single season. This system could carry in perpetuity only about six people per square mile. The warlike Bemba state to the east had a more elaborate variant of this system (Richards, 1939): they lopped instead of felling the trees and then piled the branches in large circles with consequent smaller loss from rain and weeds around the margins. These large-circle gardens were planted for several years to a sequence of crops. Because of the shorter regeneration period of the lopped trees, the longer use of gardens and other economies inherent in the system, the Bemba method of land use had a higher carrying capacity than that of the Lala, possibly of the order of ten or 12 people per square mile. These systems of agriculture depend on an abundance of wood to burn, and not on the fertility of the soil itself. Other tribes cleared their gardens of trees by felling and burning but were careful soil selectors; yet they were still wide shifting cultivators. But one section of the Mambwe used more permanent gardens kept going by an elaborate system of green manuring. Many tribes also used riverside gardens, renewed annually by the silt from floods. Among the Lozi (Gluckman, 1941) who inhabit the great flood-plain on the Zambezi's upper course, the use of alluvial gardens was highly developed: their kings drained vast stretches of peaty soil at the margins of the plain to provide rich gardens. The Lozi also ridged gardens by turning in grass to provide fertile plots which would stand above the early floods. Here there was a highly developed agriculture, which Government experts said they could not improve without elaborate experiments. But since the gardens consisted of fertile pockets interspersed with large areas of uncultivable soil, they could not support dense populations. All these peoples therefore were thinly spread over the land, producing, even in a good year, little beyond what they and their families could consume.

We owe our detailed and penetrating knowledge of the shortcomings and the advantages of these African agricultural systems mainly to a brilliant team of

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research workers in the Northern Rhodesian Agricultural Department. This team was led on the agricultural side by Mr. W. Allan and the ecological basis for its work was laid down by Mr. C. G. Trapnell. I am glad to have this opportunity of paying tribute to this work, as an important basis for sound anthropological research; recently a member of the team, the late Mr. David Peters, carried out studies in the Central Barotse Plain where I had worked, and showed that an adequate agricultural study required that I modify my own analysis. But here, as Director of the Rhodes-Livingstone Institute, though weaknesses in my own work are shown, I can claim that we anthropologists were the first to recognize this. After I had collaborated in a field study of the Mazabuka Tonga (Allan and others, 1948) with the above three officers, I was able to publish in the Rhodes-Livingstone Papers not only our own study, but also to rescue, from Government files and the maws of white ants, two other studies by Allan (1949) and a report by Peters (1950). I hope the Institute will also publish Peters' work on the Barotse Plain. Allan's studies in particular include an important theoretical analysis of the basic principles of subsistence agriculture. On the basis of Trapnell's ecological surveys, in which he worked out associations between types of vegetation, soils, crops and agricultural systems, Allan set out to calculate the carrying capacity of different types of land and agriculture. The carrying capacity of such a system is that population which it can support in perpetuity—calculated per square mile it gives the critical population density. This figure takes into account the amount of cultivable soil, which over Northern Rhodesia lies probably only between 15 to 25 per cent, the fertility of the soil, methods of fertilization and rotation, and the crop used, as well as methods of cultivation. A change in any of these variables alters the critical density. Climatic factors, like six months' rain—six months' drought, also kept the population low. Allan and his colleagues calculated the critical densities of various systems, and found for Northern Rhodesia that they probably ranged from under six to somewhere around thirty only. Over vast areas low densities only were possible because the soils of the ancient plateau were badly leached, and only a few favoured areas allowed the higher densities. Many other factors produced low densities by reducing the cultivable percentage, such as presence of tsetse fly or absence of surface water. This calculation has practical importance, for once the critical point is reached it means that the people have to cultivate on soils before they are properly regenerated, and the cycle of land degradation begins. Practical problems indeed compelled Allan to elaborate his theoretical system: many tribes had been settled in reserves demarcated on the assumption that two-thirds of the land was cultivable, and with gross underestimates of the area required if a man were to have sufficient gardens to enable him to move through them and yet allow the land to regenerate properly.

Every anthropologist has to take account of the system of working land to obtain food, and so on: Dr. Audrey Richards in 1932–34 investigated the relation between this system and Bemba society and produced, in 1939, a book which remains the best study of its kind. It deals with an ash-planting people with

a relatively simple agriculture. I feel it is impertinent for me to mention my own study of Barotse society (1941) in its ecological relations in the same paragraph with hers, but I do so because I was dealing with a complex agricultural, fishing, and pasturing economy.

These agricultural studies form a basis for a study of individual societies; in addition, they are important for an understanding of the history of the whole region. If one reads Livingstone's accounts of his long journeys between villages, the impression is of an empty land. Even to-day, when one flies over miles of seemingly uninhabited and unused woodland, one may conclude that the region is still underpopulated, despite a probable big increase since British occupation. But as a result of the work of Allan and his team we now know that the African systems of agriculture could only support sparse populations, and that despite the appearance of plenty of land, pressure might be heavy. This may well have been an important cause of those constant migrations of people which recur in African history, when tribes and nations split and sections embarked on careers of conquest. This is plain where populations are obviously dense, but the important factor is critical density for the system of production and not absolute density. Certainly the picture we are building up of early African history is of constant marches of conquest which led to the creation of small empires. But these small empires had little internal stability because their internal economic relations were scarcely differentiated (Gluckman, 1954). Hence when pressure became great again sections of the empire would themselves start on careers of conquest, or in the wider spaces of their new homes the empires would disintegrate. There are, of course, exceptions to this general picture, in specific places: an important one in Central Africa is the Barotse Plain. Here a complex environment, differing markedly from surrounding regions, led to a highly complicated system of exchange of goods (both by barter and by tribute to the king who redistributed it among his people) which seems to have given great stability to the empire. I have suggested (1941) that whoever ruled in the Barotse Plain was bound to dominate the region, as whoever held London was bound to dominate England.

At the period when these peoples come into our recent knowledge then, they show us conquering hordes sweeping across the land to establish an ephemeral empire over other small states or over tribes without state-like organizations. And some of these latter people persisted unsubdued in various areas. The conquering hordes during last century were also set in movement by contacts with Europeans and Arabs, and by the acquisition of muskets and thus superiority in weapons. The most notable of the former type were the northward marches of groups from the Natal-Basutoland region. Here there had existed from at least the fifteenth century a polity of small tribes, moving steadily southwards and westwards, rarely subduing their fellows but in relations of alternating peace and war with them. About 1770 this movement came into conflict with the Cape colonists, and the repercussions led to a series of struggles in the present Natal-Zululand region in which some tribes came to dominate their neighbours. These dominant groups then fought each other and the Zulu emerged triumphant.

But sections of the defeated started on headlong marches of conquest and set other tribes going on similar careers. Altogether the following states emerged besides the Zulus: the Shangana of Mozambique, whom Livingstone saw as Landeens drawing tribute from the Portuguese at Tete; the Basuto under Moshesh; the several Ngoni or Mazitu kingdoms of Central and East Africa, some of whom reached Lake Victoria Nyanza; the Ndebele of Southern Rhodesia; and the Kololo who, under Sebituane, conquered Barotseland for a time and helped Livingstone on his first transcontinental journeys. Earlier, the great Lunda kingdom in the Congo basin, under Mwatiamvo, had sent out sections to conquer around the headwaters of the Zambezi, on the Luapula, and the Chambeshi. Other empires were established by small groups armed with muskets, notably the Garenganze (Yeke) kingdom of Msidi in Katanga. The Yao who, possibly under the pressure of Arab slavers or other tribes, moved from the Rovuma River round the south of Lake Nyasa, conquered widely. Here, between Livingstone's visit in 1860 and his return a few months later, they burnt, destroyed and enslaved a happy and populous people. In this region too, Portuguese half-caste traders built little states, and further north this was the policy of Arab slavers.

This general process, involving the rise and fall of small empires, presumably proceeded in Central Africa for centuries. But previous to this period there had existed in Africa states on a more developed economic basis. The archaeological evidence (Caton-Thompson, 1931) that Zimbabwe and other ruins in Southern Rhodesia, the Transvaal and Free State (and possibly Angola), were built by Bantu-type people seems definite. These people were mining gold, nickel and silver to considerable depths, they had large stone buildings, and irrigated terraced gardens. They were trading through Arab ports such as Sofala to Arabia, Persia, India and beyond to China as far back at least as the tenth century. Archaeology, anthropology and history have still to study adequately these states and why they have passed away. It seems probable that they existed as islands surrounded by peoples at the stage of technological development found in the nineteenth century. I mention them for they show that there was a period when Bantu technological development was greater and they indicate the long period during which external trade has existed for the region, with unmeasured influence on political events.

I have sketched the general political history of the region up to the major arrival of Europeans. What problems does this history present to the anthropologist? Here I must turn to the history of anthropology outside the region. Modern anthropology is only some thirty years old. We owe a great debt to the missionaries, explorers and administrators who have left us accounts of contemporary life. Pre-eminent among the early ones were probably Livingstone, whose balanced reports on the Kololo and other peoples are invaluable, and Duff Macdonald on the Yao. Later, Dr. Edwin Smith, who was to become President of the Royal Anthropological Institute, with the late Captain Andrew Dale produced *The Ila-speaking Peoples of Northern Rhodesia* (1920) which still ranks as one of the classic comprehensive accounts of an

African people. Our admiration of this work was expressed in the dedication to Dr. Smith of the first symposium published by the Rhodes-Livingstone Institute. But I know that Dr. Smith would join me in the judgment that his own work, with its attempted coverage of every phase of Ilia life, is of a type which does not lend itself to systematic analysis; and that the modern professional field-worker making such a systematic analysis collects and presents more detailed and interconnected material. It is no slight on our predecessors, but a tribute to them, if we feel that by their aid we have surpassed their standards. These writers, and others like Bullock, Doke, Coxhead, Gouldsbury, Sheane and Melland were concerned to describe the customs and practices of a people completely. To-day the anthropologist, both in collecting and in analyzing his facts, attempts to show how each society exists as a system of regularities within its environment, and its foreign relations. In Africa, the first work of this kind was done in the Anglo-Egyptian Sudan by Professor Evans-Pritchard. For the problems with which I am here concerned, the nature of political society, his pioneer work was on the Nuer (1940). They are a people without governmental institutions, one of those societies where rights are theoretically secured by self-help and the threat of the feud. Evans-Pritchard was able to present for us the mechanisms by which such a society maintains internal order and organizes for war, and by which its social structure, as an ordered arrangement of social relations, persists through time. His work was followed up by anthropologists in other parts of Africa. In Central Africa we have so far reports on only one society of this type, the Mazabuka Tonga, though studies have been made of the Yao and Lakeside Tonga of Nyasaland, and the Mambwe and Cewa of Northern Rhodesia, who have very small chieftainships. For general sociological theory all these studies are important; but the Mazabuka Tonga presented to Dr. Elizabeth Colson a series of particularly fascinating problems. They had been badly smashed by raids from an unknown chief Pingola and later by Kololo, Ndebele and Barotse. They may once have had some form of chieftainship, but it had disappeared. They lived in small hamlets of kinsmen related in many lines, but who were frequently altering their residence. Their important kinship group consisted of a number of people related by maternal descent, who were scattered over a neighbourhood. This group was supposed to take vengeance for wrongs against its members, to protect its members, and to support them in all crises. It shared inheritances, and contributed to marriage expenses. But it kept dividing and had no local centre so that it was, over the generations, ephemeral. What was fixed was membership of 12 matrilineal clans, which spread among surrounding peoples. Numbers of these clans were linked together as 'joking partners', and had the right and the obligation to upbraid one another for certain offences: breach of the rules of exogamy which compel intermarriage and establish links between different sets of peoples; attempted suicide with its denial of the value of life; wastefulness with property; intolerance and aggressiveness in social relations, and so forth. The clans are widely dispersed and have no ritual cults, but they are the only persisting and enduring units of Tonga society and through the joking system they are associated with these

fundamental social values. Joking partners are outsiders, unrelated people, who by gibes enforce observance of these values. However, Tonga belong not only to clans and to matrilineal kinship groups; they also have ties with their fathers' matrilineal group, they are members of hamlets, and they are members of neighbourhoods around those villages. And though there is no person who has authority in a neighbourhood, each neighbourhood is dependent for communal good fortune on a group of shrines tended on by a certain family. Ritual is performed at these shrines for rain and for relief against epidemics. The shrines are ephemeral, and it seems likely that their distribution at any one time corresponded with altering alignments of social ties; but they represent the common interests in rain, good crops, freedom from epidemics, and so on, of individuals who live together. Yet the other ties pulled these individuals in other directions into association with members of other rain-shrine communities. Dr. Colson, in a series of important articles, has analyzed these varying sets of ties. She has shown that despite the apparent absence of any sort of authority, some redress for wrongs and attainment of rights was achieved because individuals were subject to conflicting loyalties in the various sets, so that, to put it strongly, their friends in one set were their enemies in another. In an article on 'Social Control and Vengeance in Plateau Tonga Society' (1953) she has analyzed how this can bring about a settlement of a dispute even though there is no one with authority to back a judgment on rights and wrongs. I know of no society which brings out so well as Tonga society does the importance of the many-sided social affiliations of every individual and group; and I may add that I know no better series of analyses than those written by Dr. Colson. The significance of this principle has also been worked out by other officers of the Institute among the Mwinilunga Lunda, the Yao, and the Mambwe, and by Dr. Barnes and myself for the Fort Jameson, Ngoni and Barotse States. Outside our ranks, Professor Monica Wilson, wife of our first Director, has done this for the Nyakyusa of Tanganyika.

Part of the importance of Dr. Colson's study lies in her analysis of how a series of kinship ties, born in the family, are built into a political structure. Again, this is a general problem which has been tackled by all our officers. I take the work of Dr. Clyde Mitchell on the Yao. The Yao are an Islamized people dwelling in the Shire region of Nyasaland; they entered the region as slavers and came to blows with Livingstone and Bishop Mackenzie, who were forced into resisting their attacks on the Nyanja indigenes. The Yao were organized in small chieftainships largely built on domestic slavery, and they, with the Bisa, were for a long time intermediaries in the slave and ivory trade from the interior to the Portuguese and Arabs of the East Coast. In return they obtained chiefly cloth, trinkets, and gunpowder. Though they were organized in small groups, their fire-power enabled them to conquer and raid successfully. The Yao have a matrilineal descent system—that is, they trace descent, for purposes of succession, from mother's brother to sister's son. Every ambitious Yao, in common with every ambitious Central African, strove to build around him a group of followers. There were two ways of doing this: by capturing and holding slaves, and by

keeping the female members of one's matrilineal descent-group and their children. Mitchell has analyzed the political system of the Yao as a system of villages united through their headman with a chief who is *primus inter pares*. He has related the superstructure of these political relations to the history of the people through the institution of 'perpetual kinship', by which two political positions are established in permanent relations of a particular kind of kinship. Each incumbent who succeeds to a position takes over this relationship whatever his personal ties of kinship with the occupants of other political positions. This superstructure is tied into kinship relations within villages. Mitchell also examines the manner in which charges of witchcraft and divinations of the ancestors' will are manipulated by individuals in serving their interests within these systems of relations, which contain sources of conflict through contradictions in their rules. Mr. Turner is developing this kind of analysis for the Mwinilunga Lunda.

I consider Mitchell's study of perpetual kinship to be an advance on work done on this problem in other parts of Africa. It is supported by an equally valuable study by Dr. Ian Cunnison of a similar institution in the great Kazembe kingdom of the Luapula River. Cunnison has produced an almost mathematical analysis of how these institutional arrangements operate to stabilize these political structures at a particular size. He shows how the kinship terminology, modes of succession, ritual observances, and so on are all involved in this process. His study of *History on the Luapula* thus makes clear the danger of using African (or other) genealogical records as a means of dating the complex history of the continent. He also develops skilfully a series of problems posed by Evans-Pritchard, the problem of the coexistence in a single social system of subsystems each of which has involved in its structure a different sequence-scale of events. Thus he opens up a new field of research. I can perhaps best summarize these problems by English examples: England's history involves the separate histories of the land as a whole, of the monarchy, of Parliament, of Oxford colleges and London livery companies, and so forth, and all of these histories are involved in one another. The working out of this complex process is obviously a fascinating field for anthropological research. His work has been followed up and demonstrated in a different type of system by Dr. Watson on the Mambwe; and it has been separately treated by Barnes and Professor Margaret Read on different Ngoni tribes.

I have said that in the history of anthropology the critical problem in studying societies without governmental institutions has been to work out how they maintain themselves as an ordered system of relations, and resist internal disorder and external attack. When we approach societies organized as states with governmental authority in a familiar pattern of delegated authority, some of the institutions which achieve these ends are obvious. There are legislative, administrative, military, and judicial officers. In these states modern research has become primarily interested in extracting the divisions and conflicts which exist within the system of authority, and showing how these are built into the state system, so that conflict itself becomes a basis of social cohesion. These are problems in

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which I have myself been particularly interested: they were thrown into my lap by the Barotse social system itself. The Barotse state has a very elaborate central political authority where there is explicit representation of the different elements of the state—what we call King, Lords, and Commons. I have been able to indicate (Gluckman, 1951) how even in these simple economic systems, where there exists little conflict of interest between different functional groups, the very existence of authority arouses certain conflicts. These are then met by certain countervailing institutions which exist throughout the governmental hierarchy. The processes involving these institutions are thus not simply consistent but are in fact opposed to one another, so that through a period of time, despite changes in personnel, quarrels, and so forth, the processes operate to compensate one another and re-establish the pattern of relations. I cite only one important conclusion, that in these systems a civil war does not break up but maintains the political system as a whole (Gluckman, 1951, 1954b, 1954c). This process works through an elaborate division of institutions, which has been demonstrated in detail through several systems. There are, of course, other problems involved in authority systems. Again, one example must suffice to exhibit these. In all our societies we have been interested in the position of the village headman—the man who stands at the bottom of the administrative hierarchy, and yet is mixing constantly with the subjects. He is a subject and a ruler at once. This exposes his position to great strains and raises a problem of general interest, for it is similar to the position of the factory foreman, the school prefect, the political party whip, and so forth (Gluckman, Mitchell & Barnes, 1949).

A number of specialized studies fall into the political field, which throughout Africa have yet to be worked out thoroughly. As we begin to understand how African political systems are constructed we have to pass to an analysis of how they work. This involves separate treatments of law, of warfare, and of administrative and legislative decision. It is in the study of African law that studies in the region have so far made the most notable contributions. And here I must first express my admiration of the studies by Professor Schapera of Tswana law and legislation, in an area just to the south of our own, for these have been a constant guide to my own work on these problems. Godfrey Wilson (1949) and I (1943a) have published analyses of the land-tenure systems of the Nyakyusa and Barotse in relation to their social structure, which I believe are the main theoretical treatments of this subject. I also drew attention (1943a) to a distinction made by the Barotse between tribute and royal goods which is intrinsically interesting and also significant when we consider the problems of technical development in African jurisprudence. But here our most important work has been on the African judicial process. Similar work on non-Western societies has only been done by some American anthropologists. I myself (1954a) after several years of writing am just publishing a study of the judicial process among the Barotse which I feel I may justly call a pioneer work. It draws attention to the existence of the reasonable man in African law and develops some of the implications of his character. It also considers for these systems the existence

of the law of nature and the law of nations, and the use of equity, the relation between law, custom and morality, and the judicial use of knowledge of the physical laws of nature. Finally, it concludes by examining the relation between certainty of legal rule and uncertainty of judicial decision. These are perennial problems of jurisprudence. They have been examined independently by Mr. A. L. Epstein (1954; 1953) in two excellent studies of the institution, development, and problems of the African Urban Courts established by the Northern Rhodesian Government in towns. I plan to follow my study of the reasoning of law with studies of the political problems of law, and the relation between Barotse ideas of jurisprudence and their social structure. Meanwhile, Dr. Holleman (1952) has produced a detailed study of Shona law, in Southern Rhodesia, which parallels Schapera's *Handbook of Tswana Law and Custom*.

The most important study of administration so far published is by Barnes on the Fort Jameson Ngoni (1954). But this book also marks a different development in anthropology in general, in which Evans-Pritchard on the Senussi and Schapera on the Tswana have been pioneers. We now begin to understand the systematic structure of African societies, both through individual intensive studies and through comparing these one with the other. Our next task is obviously to turn back to their histories, in order to see how these systems functioned and changed through particular series of external events. Barnes has done this with skill and detail, and he has made full use of archival material. Wilson analyzed more sketchily the constitution of the Ngonde of N. Nyasaland. Here is an important meeting-ground for anthropologists and historians. I must confess that I am sadly disappointed in reading most colonial histories to find that they still regard the African peoples, into whose midst Europeans came, as an undifferentiated mass of savagery. Few historical studies, despite the magnificent lead set by Professor W. M. Macmillan in South Africa, make an adequate attempt to understand the internal and foreign relations which determined particular tribes' reactions to the European incomers. For these to be worked out properly, the historian must take into account anthropological analysis, and weigh it against the direct evidence of contemporary records which were often biased by particular viewpoints and by ignorance of the workings of an African society which has been unable to leave its own written records. I find it striking that the only historian of the slave-trade who has examined why some tribes refused to deal with the slavers while others did so and yet others became their agents, is Mr. L. H. Gann, who as an officer of the Rhodes-Livingstone Institute worked closely with anthropologists. In other problems too he has shown an awareness of problems arising from the nature of African tribal society, a quality which I find lacking in his colleagues.

The classic field of anthropology since its early years has been the study of kinship and ritual. I have touched on the manner in which kinship relationships are tied into the political structure and on how this problem has been handled by Colson, Cunnison, and Mitchell. Otherwise, most important work in this field concentrates on two sets of problems. The first arises from marriage, where Dr. Audrey Richards set the lead with an excellent study of *Bemba Marriage*

and *Present Economic Conditions* (1940b), which is the first full study of marriage for an African matrilineal system. Later she followed this with a comparative study of matrilineal systems throughout Central Africa, published in a symposium on *African Systems of Kinship and Marriage* (1950). In that symposium I presented a hypothesis that jural stability of marriage is associated with a patrilineal form of kinship organization, and jural instability of marriage with other forms, by comparing the Lozi of Barotseland with the Zulu. This hypothesis has been taken up and is being checked by my colleagues. Barnes has already approved of it for changes in the marriage system of the Fort Jameson Ngoni, which he worked out in detail (1949). He has also, in a separate paper, set out better methods for measuring divorce rates in societies where marriages and divorces are not registered. This is essential as we come to compare societies with smaller differences of rates than those of the Zulu, with no divorce, and the Lozi, with many divorces. This paper of Barnes' is also important as signifying one valuable development of the Rhodes-Livingstone Institute's programme, the elaboration of statistical and quantitative work which becomes increasingly important in order to refine our accumulating qualitative knowledge. Here Barnes, Colson and Mitchell have given a lead which later officers have followed, and, in the absence of good population data, these anthropologists have made important contributions in analysis of small sets of demographic data (Mitchell, 1949b; Colson, 1954).

Barnes' paper on Ngoni marriage, like Richards' earlier study, also examines the internal balance between different kinds of kinship relations in different systems. This second set of problems has been taken up by Colson, Mitchell, Turner and Watson. Here they have principally examined how kinship ties, generational association and local settlement are interwoven. The main publication, however, falls on the borders of the region, Professor Monica Wilson's *Good Company* (1951), which analyzes the unusual system of villages of age-mates among the Nyakyusa.

There has been less work on the problems of ritual, but these are being tackled in a sociological manner. During the early years of anthropology scholars tended to interpret ritual practices and beliefs by working out how they themselves would have come to formulate beliefs or how they would themselves in practice operate the beliefs. Evans-Pritchard started us on a new line of analysis when he showed how the Azande of the Sudan use beliefs in witchcraft oracles and magic to cope with the misfortunes of life and relate their misfortunes to disturbances in their social relations. His study of how these beliefs and practices are systematized and maintained is so sound that we have been able to apply it throughout the region. But he also indicated the important connection between the types of persons who are accused of witchcraft and the structure of a particular social system. Several workers have been pursuing and refining this analysis: Colson on the Tonga, Marwick on the Cewa, Mitchell on the Yao, Turner on the Lunda, Watson on the Mambwe, Wilson on the Nyakyusa. Again, it is become a truism to say that a cult of the spirits of the kinsfolk is related to the kinship organization of a particular society: the significant sociological line of

advance is to examine how, like accusations of witchcraft, particular ascriptions of misfortune or prosperity to certain spirits are connected with particular alignments of relations between the people involved at a certain time. When this is done, we shall begin to understand the processes which relate these systems of ritual to particular types of structure. Here Colson and Mitchell have again opened up important problems; and Turner and M. Wilson are engaged on studies which I believe will be of outstanding importance.

There are two major weaknesses in all this work. The first is the relative absence of detailed economic studies. Richards, Brelsford, Deane and myself have touched on these problems; but the Institute despite several years of search has failed to find an economist willing to do the necessary fieldwork. This is a general weakness throughout British anthropology, and only one member of our Association of Social Anthropologists of the British Commonwealth states that he is especially interested in economic problems. I have not the space to examine why this should be so. The second weakness is that we have all been so busy with presenting the results of our individual studies, and with other work in teaching and administration, that none of us has had the opportunity to pull these different analyses together. Godfrey and Monica Wilson have written a most stimulating book which covers events in the region, but they were primarily interested in social change. I hope that we shall soon see a series of comparative studies to cover the indigenous institutions of British Central Africa.

I set out in appendices what tribes and what kinds of social relations we have studied satisfactorily. There is no doubt that in the last twenty years we have acquired a knowledge of the peoples of British Central Africa that cannot be surpassed for any other part of the continent. And we have not yet published all the results of the field-research that has been done. There are many peoples and problems yet to study, but taking into account the total small strength of British anthropology, and our ignorance in 1930, the achievement is considerable. It is also of high quality. Furthermore, most of this work has been done by scholars working in co-operation, tackling similar problems, collecting figures on similar bases, and so forth. The next decade should see this work come to fruition. For I believe it will appear that the considerable financial investment in the Rhodes-Livingstone Institute will be not only justified by individual studies and by general development of public interest in the region, but also that it will exhibit a co-ordination that would be lacking if the research had been carried out by individuals from separate university departments. Singly and collectively the research will have made important contributions to our knowledge of Africa and of human society; as an anthropologist, and as a person interested in my fellow creatures, I believe that to be sufficient justification of our work. I consider that this research also discharges a duty that Britain owes to the Africans themselves. This duty was put by Viscount Bryce to the Swiss missionary Junod: the exhortation made Junod change from entomological to anthropological studies, and gave us a series of great books on the Tsonga of Mozambique. Bryce said: 'How thankful should we be, we men of the nineteenth

century, if a Roman had taken the trouble fully to investigate the habits of our Celtic forefathers! This work has not been done, and we shall always remain ignorant of things which would have interested us so much!"

Central Africa is now one society. It has become a territorial region inhabited by people of different ethnic origin, recognizing different values, having markedly different customs, but who are all in relationship with one another. They are bound together in a common political and economic system; and the effects of movements in this system influence every part of the lives of all the different groups. Hence most anthropologists, in treating the structure of indigenous institutions in African tribal groups, have described how these have changed in modern conditions: political systems, law, kinship relations, economic relations, productive processes, and so forth. Practically no work—and this is true of the rest of Africa, save for a few books—has been done on the effects of missionary evangelization or of schooling, the work of the educationist. It is very important that the professional purveyor of white culture, as one of my colleagues calls him, should be investigated.

Perhaps the main foci of social change are the towns, and here anthropologists have been doing more and more work. In Southern Africa the pioneer work in this field was done by Dr. Ellen Hellmann in Rooiyard, a Johannesburg slumyard, and the Rhodes-Livingstone Institute was proud to publish it after it had lain for ten years as a thesis. In Central Africa itself, the pioneer work was done by the first Director of the Institute—the late Godfrey Wilson. He had previously done research in South-West Tanganyika on the Nyakyusa tribe, and when he came to Northern Rhodesia he immediately began an investigation in Broken Hill of the processes of urbanization. He published his results in a characteristically penetrating analysis which is a classic in the field (G. Wilson, 1941 and 1942). Further research in the urban areas was not undertaken until after the war. Then Dr. Mitchell began a study of the sociography of the Copperbelt, using a team of African research assistants. In this, he collected the basic quantitative data on population structure, ethnic origins, education, and so forth, which must be gathered for an analysis of a heterogeneous social system (see Mitchell, various). His work has now extended to cover Broken Hill and Lusaka, and Miss McCulloch has made a survey of Livingstone. All the towns on the Northern Rhodesian railway line have been covered. Similar surveys had been done by Ibbotson and Gussman in Southern Rhodesia, though they were not as detailed, and were oriented largely to problems of subsistence. Mitchell, and other members of the Rhodes-Livingstone Institute, have also data on these problems, though they have just begun to publish. Mrs. Thompson (1954) has published a short study on dietetics in Lusaka. Miss Elsey Richardson, of the Rhodes-Livingstone Institute, is engaged on a full study of family economics and dietetics.

These sociographic surveys raise different sorts of problems. They raise the whole problem of what is urbanization, which Mitchell is attempting to refine (Mitchell, 1954d). They involve the working out of age and sex structure of the population, influence on behaviour of period of residence in the towns, and

so forth. The tribal and national origins of the mixed populations of towns are also important, for they form important bases for social groupings. These studies lead on to a sociological analysis of the town situation, on which Mitchell has begun to write. Mr. A. L. Epstein had earlier, for the Colonial Office, here made a study of African Urban Courts, and now he is following this up for the Rhodes-Livingstone Institute with an analysis of the administrative and political problems of a Copperbelt town. I have not time to indicate the full complexity of the field in which these scholars are working. On the one hand they are deeply concerned with towns which have been established recently by heterogeneous groups and individuals, but which on the other hand very early exhibited an internal order and regularity of action. The towns of Central Africa are towns. Order was brought into them by the governments and industrial enterprises which established them. But towns based on mining or commerce, or both, impose their own patterns of relations and of behaviour. The African who leaves his tribal area and enters a town changes his modes of action immediately: he does different work, associates with different people, becomes subject to different authorities, and so forth. An African miner is a miner, an African townsman is a townsman. This sets one range of problems. But it does not deny that an African's actions are not also continually influenced by the culture of his own tribe, or by his difference of tribal origin from some of his fellows and of common tribal origin with others, or by the varied length of his residence in towns, and other factors. These are significant. But the patterns of the towns explain the development of other social relationships and the rise of trade unions and similar 'Western' forms of organization. The marriage of these two sets of data and related problems presents problems of great sociological and statistical complexity, with which Mitchell and his associates are battling.

The towns impose their own patterns, and the effects of their establishment, and of the industrial opportunities they offer, dominate developments in the rural areas. All the tribes have been substantially affected by the need to get money, whether by the sale of crops or fish or cattle or by the sale of labour. Richards's classic study of the Bemba (1939), Read (1942), and studies in South Africa, as well as Government Commissions throughout Africa, drew attention to the way in which large-scale migration of men to the mines disturbed and impoverished tribal life. Schapera in a study of labour migration in Bechuanaland gave a clear overall analysis of the situation, and of balancing forces. Now Watson (unpublished) has made what I consider to be the fullest study for Central Africa of the effects of labour migration on tribal structure: he shows that the Mambwe by mobilizing their labour through co-operative groups of kin have profited from the new situation. Some tribes near to markets have done so by the sale of crops, eggs, chickens, and so on. (Allen and others, 1948; Colson, various.) The reaction in different tribes to the new situation has varied, and the Rhodes-Livingstone Institute is preparing a symposium on this theme.

Investigation of the links which build up the region's politico-economic framework is only partially anthropological. Miss Phyllis Deane has published an analysis of the national income of Northern Rhodesia and Nyasaland for

two selected years, and there are of course numerous government economic reports. But we need analysis of the whole problem of how Africans get to work; Niddrie has made a beginning on this point. Miss Elliot collected statistics on the overall labour migration situation in the territories: these have still to be analyzed.

There are few histories of political and administrative developments. Dr. Hanna has written an unpublished thesis on foreign relations in Nyasaland in 1875-95, and Gann has in preparation a history of events in Northern Rhodesia up to 1924. There is a bare history of the Northern Rhodesian Legislative Council. Histories of Southern Rhodesia are more numerous. Lord Hailey's surveys are useful, as are the now out-of-date Pim report on Northern Rhodesia and Bell report on Nyasaland. But detailed analyses of governmental and administrative problems are badly needed. When adequate studies of these types have been provided we shall begin to get a general view of social developments in Central Africa which will illuminate and be illuminated by the individual tribal and urban studies. The Rhodes-Livingstone Institute hopes soon to produce a symposium which will examine what colonization and industrialization have done to the region.

DISCUSSION

SIR SELWYN SELWYN-CLARKE, K.B.E., C.M.G., M.C. (Chairman, Commonwealth Section Committee): It was interesting to learn that some African peoples in Rhodesia had been settled in reserves demarcated on the assumption that two-thirds of the land was cultivable, whereas only one quarter of the soil was actually cultivable at the time.

As regards Mr. Allan's estimate of the actual population density of various types of land and agriculture in Central Africa as ranging from six to thirty persons per square mile, you may remember that at the first census in England, at the time of the Domesday Book in A.D. 1086, the density of population was said to be 26 compared with our 700 per square mile now.

Would our lecturer enlarge on his reference to Zimbabwe? I understood Professor Gluckman to say that the African inhabitants, at the time Zimbabwe was built in the tenth century, were as far advanced in technological development as European nations in the nineteenth century. What brought this golden era to an end? At least it gives the lie to the repeated statement that the African can never compete with the European in intellectual development and achievement. I can well appreciate our lecturer's disappointment that most colonial histories regard African peoples as 'an undifferentiated mass of savagery'. You will recall that Professor Gluckman's work on judicial process amongst the Barotse drew attention to the existence of the reasonable man in African law.

Would the lecturer elucidate the following points which he made in his address: that joking partners are outsiders, unrelated people who by gibes enforce observance of these values; and that ignorance may be a necessary attribute of authority as, indeed, it is a frequent attribute?

The last sounds to me rather a crack against administrators, of which body I was once a humble member, and Professor Gluckman may like to qualify his remark. The first Governor under whom I served 36 years ago, and whose widow, Lady Moore-Guggisberg, is with us this evening, fully appreciated the value to the administration of anthropological research. He appointed a senior political officer, Captain R. S. Rattray, an anthropologist of no mean distinction, to study the Ashanti and various African peoples in the northern territories of the Gold Coast. This

study was very useful in the early nineteen twenties, when thousands of Ashanti were investing Kumasi at the time of the desecration of the Golden Stool, and prevented much bloodshed.

THE LECTURER: The history of Zimbabwe is really outside my field and I could not say why it decayed. It seems it must have been a process like the inroads of the barbarians in Europe; these civilizations were probably surrounded by other tribes who were largely instrumental in destroying them.

As regards joking partners, there are in very many relationships, in many simple societies, and among ourselves, standardized joking relationships: Professor Radcliffe-Brown's theory is that there are two contradictory elements in the relationship, the element of hostility, and the element of friendship, and this is resolved by joking. The standard case is between brothers-in-law, as against the relationship of the mother-in-law where the conflict is solved by avoidance. In the case of this particular institution, which is very widespread in Central Africa, certain clans, or members of these clans, are in this joking relationship permanently. They are members of different clans; in this way they are allowed to joke with each other and gibe at one another. It is a very important rule, for example, that people should not marry their own kinswomen, but should marry into other groups; this establishes a friendship. If a man wants to marry a kinswoman, his own kin do not attack him, but his joking partners do, and because of the relationship he cannot protest. Thus if a man is wasting property, his own kin who have claims in that property would be put in an awkward position if they were to rebuke him. The joking partners do it.

The Tonga are a people moving over the ground with no attachments to the land, and so on; the permanent groups appear to be the unimportant ones, thus the 12 clans, in this set of relationships, have as their main duty to protect the fundamental values of the society. You must not marry your kin; you must not waste good property; you must be generous to your kin, and so on.

I suppose my remark about ignorance of administrators is part of my own joking relationship with them. It is a joke not against administrators, but against academics. Academics can afford to study all the attributes of a situation because they do not have to take a decision. A decision has to be taken quickly, very often without waiting to study the problem. Also, frequently, since there are major conflicts present in the society, the decision then has to be taken in the knowledge that it will have unpleasant results for certain people. Hence it may be better to be to some extent ignorant of what is happening. I do not say that it is so, but it may be. We saw this recently over Crichel Down. We have a national agricultural policy that is inevitably going to cause hardship to some people, and if one worries too much about all the hardships caused, one becomes like academics, unable to take a decision.

MISS LUCY WEIR: Would Professor Gluckman elucidate a little more his remark about Zimbabwe and the nineteenth century? When I first heard it, I thought he was saying that the technical level of the Zimbabwe period was equal to that of Europe of the nineteenth century, which obviously could not be so because of the European mechanical inventions.

THE LECTURER: What I meant was, that when we learnt about these African peoples from Livingstone, they were at a technological level based on the spear and the hoe, and so on. This was the Bantu in the nineteenth century. I then said that some centuries previous to this, the Bantu had a higher technological development than that of the Bantu of the nineteenth century. It was not a comparison with the Europeans of the nineteenth century. But therefore I would agree with Sir Selwyn Selwyn-Clarke that to make out an assumption about the Bantu capacity for technological development on a basis of what we found in the nineteenth century is

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unwarranted. It is as if we were to make assumptions of what the Romans could do on the basis of what the vandals brought to Rome.

A vote of thanks to the Lecturer was carried with acclamation; and, another having been accorded to the Chairman, the meeting then ended.

APPENDIX I: TRIBAL STUDIES

NORTHERN RHODESIA

Lunda-Lulu Group: Several articles on ritual by White (various), Gluckman (1949) and Turner (1952). Lunda village analyzed by Turner (1955). Turner has completed three years research and is preparing analysis.

Barotse Group: Analysis of ecology, economy, politics, and kinship, by Gluckman (various) of dominant Barotse group. Other tribes only Clay (1946) on Mankoya history. In preparation Peters (forthcoming) on Lozi agriculture and by Gluckman on Lozi law and history.

Ila-Tonga Group: Smith and Dale (1920) produced excellent comprehensive old-style monograph on Ila. Ila should be further studied, with this monograph as a base. Agricultural-economic survey of Plateau Tonga by Allan and others (1948); and excellent analysis of politics, kinship, and ritual structure, by Colson (various) who engaged on major analysis of kinship and domestic life. Other sections of group not studied and Sala-Solali impeded and the Valley Tonga.

Lamba-Ludu-Kaonde Group: Good agricultural studies, by Allan (1940) and Peters (1950). Good old-style monograph by Doke (1933); and two analytic surveys of Lamba (Barnes and Mitchell, 1950) and Kaonde (Watson, 1954). Village structure. Further research required.

Luapula Peoples: Preliminary survey (1950) and analytic study of historical concepts (1951) by Cunnison, who is about to rewrite full analysis of political system.

Bemba Group: Full studies of social organization of main Bemba tribe in relation to system of producing and sharing food (1939) and of marriage (1949), with shorter studies of kinship, politics, etc., by Richards. Several facets by Brelsford (various) and theoretical treatment of political system by Gluckman (1954c). Brelsford has written a paper on Aushi tribe (1946) and Watson is engaged on year's study of Lungu. Most important tribe in this group which is not yet studied is Bisa.

Chewa Group: Preliminary reports from Marwick, chiefly on witchcraft.

North Rhodesian Ngoni: Excellent analysis of history, politics and kinship by Barnes (various).

Mambwe: Comprehensive manuscript report by Watson has still to be prepared for publication.

NYASALAND

Ngonda-Nyavusa Group: Excellent studies of village-structure, by the Wilsons (various), and preliminary reports on other problems, especially land-tenure (G. Wilson, 1938) and politics (G. Wilson, 1939). M. Wilson engaged on analysis of ritual.

Tumbuka-Kamanga-Lakeside Tonga Group: Ethnographic notes, by Cullen Young; field study under way. Van Velsen.

Yao-Nyanja Group: Excellent preliminary papers by Mitchell, on politics, kinship and village organization; full study of village structure in press. Loumwe in the area should be studied next.

Ngoni Group: Gomani's Ngoni have been studied by Read and book in press; she visited the Nzimba group, which should be studied in detail.

SOUTHERN RHODESIA

There has been little professional work in this territory. There are numerous articles and two ethnographic books by Bullock.

Shona Group: Holleman has begun the immense task of tackling this group with an important book on law, short books on kinship and ritual, and a general account. He is still engaged in writing-up. More work in this group is urgently required, and the Ndau seem to be the next which should be tackled.

• Ndebele Group: The kingdom was badly shattered in war with the colonists, and the people scattered. There are some old ethnographic accounts of varying value: Hughes has studied the group and his first publication is in press.

SPECIFIC RURAL PROBLEMS

Studies have been made of labour migration and of the development of cash-cropping and fishing in certain areas, but no studies have been made of the new type of African peasant farmer, holding land on different terms, either in Northern Rhodesia or Southern Rhodesia.

URBAN AREAS

There are numerous Government and other reports in both Rhodesias, but the only ones of social anthropological value are by Wilson (1941-42), Mitchell (1953-54), and Epstein (1953, 1954a). Mitchell, Epstein, Richardson and McCulloch are preparing reports on research done. No sociological study has been made of European or Indian groups or of modern functional groups such as factories. Here the field is so untouched that individual problems need not be detailed.

APPENDIX II: PROBLEMS INVESTIGATED

TRIBAL INSTITUTIONS

Agriculture: Sound basis laid by Allan (1948); Trapnell and Clothier; Allan and others (1949); Peters (1948 and forthcoming).

Social Ecology: Main problem in Richards (1939) and Gluckman (1941). Covered in Barnes, Colson, Cunnison, Holleman, Mitchell, and Watson (unpublished).

Historical Sociology: Barnes (1954); Gann. More work required.

Economics: Allan and others; Deane. Much more work required.

Political Structure: Several studies by Barnes, Colson, Cunnison, Gluckman, Holleman, Mitchell, Richards, Watson, the Wilsons; require studies of Ila, Bisa, Congo Lunda, Tumbuka.

Kinship Studies: Several studies by above authors; some tribes require studying.

Law: Epstein; Gluckman (1943 and 1954a); Holleman (1952).

Ritual: Articles by Brelsford (various), Gluckman (1949), Holleman (1953), Marwick, White (various). In preparation, full studies by Turner and M. Wilson.

SOCIAL CHANGE

Effects of Labour Migration on Social Life: Richards (1939); Read (1942); Barnes (1951b, 1954); Watson (unpublished); Rhodes-Livingstone Institute (in preparation).

Effects of Cash-cropping: Allan and others (1948); Colson (various); Connison (unpublished).

In Tribal Politics: Barnes (1948b, 1954); Colson (1948); Mair; Mitchell (1949a). More publication required.

In Kinship: Several.

Urban Studies: Wilson (1941-42); Epstein; Mitchell (various); much more required.

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Bibliographies on all the peoples of the region, some of which are annotated, are contained in *The Ethnographic Survey of Africa*, published by the Oxford University Press for the International African Institute. This survey summarizes data up to the date of going to press; some unpublished material is contained in them. The relevant volumes are:

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RADIO ASTRONOMY

A paper by

A. C. B. LOVELL, O.B.E., Ph.D., F.Inst.P., F.R.A.S., F.R.S.

*Professor of Radio Astronomy, University of Manchester,
and Director of Jodrell Bank Experimental Station,
read to the Society on Wednesday, 23rd March, 1955,
with Sir Ben Lockspeiser, K.C.B., F.R.S., Secretary
of the Department of Scientific and Industrial Research,*

in the Chair

THE CHAIRMAN : Shortly after the war I was sitting in my office, when a young man came and asked me to let him have £1,000 in order that he might build a radio telescope. After he had explained about his idea, I realized that he was proposing a very promising new line of enquiry, and he got his £1,000.

Two years afterwards, the same young man walked into my office and said he wanted £100,000 to build a new radio telescope. He pointed out that this would provide a new method for investigating the universe, and because it was independent of cloud and other climatic conditions which make observational astronomy in this country so difficult, he felt sure that here was an opportunity for this country to regain its leadership in this field. He produced a bit of paper with a squiggly line on it, and claimed that this was a record of radio waves which he had received with his first telescope, and which had been travelling through space for a million years. I was very impressed, and I was prepared for his view, which he pressed with considerable insistence, that what he really wanted was a huge telescope which he could point to any part of the sky and receive radio waves from any direction. He promised that if he had this, he would prepare a new map of the universe which would be even more complete than the one obtained by the great American astronomical optical telescope.

In the course of my experience I have always doubled the amount which any enthusiastic scientific research worker says he wants for any new enterprise, so I said to myself that the amount required would be something like £200,000 or perhaps £250,000. I did not say anything then, but I asked my Scientific Grants Committee, on which we take care to see that there are some good engineers, to look into the proposal in all its aspects. The Committee's conclusion was that this telescope, consisting essentially of a huge suspended steel bowl, would weigh several tons. The project was probably feasible but would cost a lot more than £100,000. After some argument, we gave this young man, whom you will have gathered is our lecturer, Professor Lovell (in spite of his disarming and innocent appearance), a few thousand pounds to spend on some good consulting engineers to go into the question of design in sufficient detail to determine the feasibility of the proposal and its probable cost.

From what I have said, you will not be surprised to hear that after the matter had been gone into, the cost was estimated at not less than £300,000. Professor Lovell returned armed with these figures and also armed with the opinion and recommendation of an eminent body of scientists, together with a very strong recommendation from the Council of the Royal Astronomical Society. Certain modifications and rising cost of materials and labour eventually brought the figure to nearly £½ million and, although we were keen enough to support the venture,

5TH AUGUST 1955

RADIO ASTRONOMY

we did not have, at the time of the financial crisis in 1951, enough to spare to meet a bill of this magnitude. Fortunately the Trustees of the Nuffield Foundation stepped in and offered to share the cost equally with us, and it was because of their generous attitude that this scheme was eventually enabled to go forward.

It had been known for some time that there are sources and bodies in space which radiate on a very much longer wavelength than those our eyes receive. If our eyes were sensitive to these wavelengths, of an order usually associated with radio transmission, we should see a very different universe around us. Professor Lovell's proposal really was that we should give the astronomers another pair of eyes and make the best of both worlds. This is what is being done at Jodrell Bank.

I have been down there to see how the work is getting on. The radio telescope is not only a great new scientific instrument; it is a magnificent feat of engineering. The steerable bowl, if placed vertically beside the clock tower of Westminster would reach up to the face of Big Ben. Some very interesting results have already been obtained from the first and rather crude telescope, and, as frequently happens in fundamental research, some unexpected results of great practical value have emerged. For instance, Professor Lovell and his team have been able to find out, from the study of meteors entering the atmosphere, a good deal about the state of the upper atmosphere, particularly in relation to winds. This is of great practical value in connection with flight at high altitudes.

I do not want to say any more than that, or I shall be getting on Professor Lovell's own territory in which he is a leading expert, so I should like first of all to extend, in your name, a very hearty welcome to Professor Lovell for coming here this afternoon, and secondly to say how much we are looking forward to his lecture on '*Radio Astronomy*'.

The following paper, which was illustrated with a film and lantern slides, was then read:

THE PAPER

THE ASTRONOMERS' UNIVERSE

The investigation of the universe by the great American telescopes during the past 25 years has been an imaginative enterprise unsurpassed in the history of man. When the 100-inch Mount Wilson telescope started its work just after the First World War, astronomers believed that the entire universe was contained within the confines of the Milky Way—a system containing millions of stars scattered throughout a roughly spherical enclosure across which light would take about twenty thousand years to travel. Moreover, it was firmly believed that the sun and solar system were at the centre of this great assemblage. However, these beliefs were destined to survive the probings of the Mount Wilson telescope for only a few years. The light-gathering power and penetration of that instrument were so superior to any existing telescope, that the scientists using it soon realized that the Milky Way system was built on an altogether more gigantic scale than had been believed. Instead of a spherical enclosure the Milky Way system was revealed to be flattened with an extension of nearly one hundred thousand light years, but only a few thousand light years thick at the centre. This system is now known to contain something between one thousand million and ten thousand million stars, with the sun and the solar system much nearer the extremity than the centre.

Even more remarkable was the demonstration by the distinguished astronomer Hubble that the confines of the universe extended far beyond this gigantic system. Over a century previously Herschel had speculated that faint nebulous objects which he could see in his 48-inch telescope might, in fact, be outside the Milky Way. This belief was resurrected, and Hubble was able to show that these nebulae were beyond doubt extragalactic and situated at enormous distances from our own Milky Way system. He found that the nearest of these was the great spiral nebula in Andromeda, at a distance which is now believed to be one and a half million light years. Many of these extragalactic nebulae are similar to the Milky Way system and each contain many thousands of million stars. The contemporary picture of the universe is, then, of a universe consisting of millions of nebulae similar to the Milky Way, distributed throughout space to distances such that the light from them takes one thousand million years to cover the intervening space to the Milky Way.

THE PENETRATION OF LIGHT AND RADIO WAVES THROUGH THE EARTH'S ATMOSPHERE

Now all this kind of astronomical research on which our beliefs about the universe are based, has been carried out with telescopes and other instruments receiving light waves emitted by the stars in the visual part of the electro-magnetic spectrum. Auxiliary instruments, such as photo-electric cells and photographic plates, can extend these studies somewhat beyond the visual limits into the infra-red and ultra-violet regions, but appreciable extension is impossible because of the absorption caused by water vapour and fine dust in the earth's atmosphere. The fact that our knowledge of the universe has come from such a small part of the total electro-magnetic spectrum has never worried astronomers unduly. The distribution of the energy in a hot body such as a star is well known and it has seemed clear that our knowledge of the universe was not appreciably restricted by this absorption in the atmosphere. This belief seemed so well founded that there was little astronomical interest in a second, more extensive gap or window in the atmosphere at very much longer wavelengths, since it seemed impossible that any of the objects studied by astronomers could emit detectable amounts of energy on these long wavelengths.

This other gap exists in the radio wave region. At its short-wave end, it is again limited by atmospheric absorption near a wavelength of a few centimetres and at the long-wave end by reflection in the heaviside layer or ionosphere at a wavelength of about twenty metres. Any radio wave generated on the earth within this waveband can penetrate the atmosphere and ionosphere and escape into space, and conversely if any radiation is being generated in space in this waveband it can pass through the atmosphere and ionosphere and be received on the earth.

THE DISCOVERY OF RADIO WAVES FROM SPACE

At the end of 1931 an American engineer, Jansky, made the surprising discovery that radio waves apparently emanating from regions beyond the solar system were reaching the earth through this window in the atmosphere. Jansky's historic

discovery was published in a radio engineering journal and it seems doubtful whether many astronomers knew of his work. In any case it caused little interest and the only important additions to his results before the Second World War were obtained by Grote Reber, an amateur investigator who built apparatus of advanced design in the garden of his home in Illinois. In fact, Reber constructed the first radio telescope of the type with which we are familiar to-day. It was thirty feet in diameter and received radio waves on a wavelength of about two metres. This instrument could be readily pointed at different parts of the sky. With it Reber confirmed Jansky's discovery that radio waves were reaching the earth from outer space and he made the first serious attempt to find out in more detail from where they came. He found that the radio signals were strongest from directions near the centre of the Milky Way, and that the radio signals were roughly proportional in strength to the concentration of stars in the direction to which the radio telescope was pointing. On the other hand, Reber failed completely to detect any signals from the bright stars or from other prominent features visible in telescopes.

This paradox led him to the view that the radio signals were being generated in the very rarified hydrogen gas which fills interstellar space. This represented the extent of our knowledge of these radio waves from space in 1945, but the six years lost to fundamental research during the war were soon to appear as a rich investment for astronomical research. By a strange twist of fate the Second World War placed in the hands of astronomers a new and enormously powerful tool for the exploration of space. The concentration of work on radio and radar for military purposes resulted in technical advances, in the space of a few years, which might have otherwise occupied a generation of research workers, and when these techniques were applied to the investigation of these radio waves generated in the cosmos spectacular results were obtained. The discoveries of the last few years have rivalled in excitement the more conventional developments with the American optical telescopes.

THE DISCOVERY OF RADIO STARS

The first measurements confirmed Reber's results and there seemed to be no direct connection between the radio signals and the astronomical objects which comprise the universe familiar to the human senses. Reber's idea, that the emissions were generated in the interstellar gas, remained for some time the only realistic suggestion but in 1948 came the first of a sequence of discoveries which stimulated the interest of astronomers throughout the world. Bolton and Stanley in Sydney, followed immediately by Ryle and Smith in Cambridge, found that at least some of the radio waves were coming from discrete or localized sources in space, subsequently called radio stars. The two most intense of these sources were in the constellations of Cygnus and Cassiopeia. If these radio sources had coincided with any prominent visual objects the discovery would not, perhaps, have occasioned much surprise, but although both lay in densely populated stellar regions there were no particular visual objects to which the radio emissions could be attributed.

Subsequently many other, less intense, radio stars were discovered and there seemed to be no correlation with any class of star known to astronomers; neither did any of the common stars appear to emit radio waves which could be detected on the earth. The belief arose that we were dealing with a new type of body in the heavens, dark or only faintly luminous but with the facility of emitting powerful radio waves; moreover, a type which appeared to be of frequent occurrence and distributed throughout the Galaxy in a manner similar to that of the common stars. For some time there was uncertainty as to whether the extragalactic nebulae might be similarly endowed with the facility of emitting intense radio waves, but any such doubts were laid to rest in 1950, when the scientists at Jodrell Bank used a very large radio telescope and showed that the nearest extragalactic nebula in Andromeda behaved in a manner similar to the local Galaxy, as far as emission of radio waves was concerned. Subsequently the emissions from many more remote nebulae were detected, and it is now widely accepted that the type of radio source responsible for the emission in the Milky Way system must be widely dispersed throughout the extragalactic star systems which comprise the universe.

THE IDENTIFICATION OF RADIO STARS

In the last few years there has been very close co-operation between the scientists using the radio telescopes and the astronomers with the big optical telescopes in America, in an effort to find a more precise relationship between the radio sources and objects which are visible in the telescopes. Although nearly two thousand of the radio sources have now been positioned, and in many cases the size and shape measured, the linkages which have been established with the common stars remain remarkably few, and the general paradox of the existence of the radio sources remains. We are, however, now certain of one connection which was suspected several years ago. Occasionally a star blows up—it becomes a supernova. The atomic processes which generate the energy inside the star get out of hand and nature gives a replica on a really gigantic scale of an atomic bomb explosion. Instead, however, of an explosion of a few pounds of uranium or plutonium, all the millions of tons of material in the star go up. Only three such explosions of stars in the Milky Way have ever been recorded. The most famous of these occurred a thousand years ago and the remains of the star can still be seen as an enormous cloud of tremendously hot gas travelling into space at a rate of seventy million miles every day. This object—the Crab Nebula—has now definitely been established as a source of strong radio emissions. In fact, it is the third strongest source in the heavens. The other two supernovae—those discovered by Tycho Brahe in 1572 and by Kepler in 1604 are also known to be radio sources, although very much weaker. Although these connections are of extreme interest, it seems unlikely that supernovae can account for more than a few of the radio sources in the Galaxy.

A few years ago, the scientists in Cambridge measured the position of the most intense source in Cassiopeia with such precision that it became possible to carry out extensive photography of the sky with the great Palomar telescope.

In the position of this radio source, the Palomar telescope has photographed a peculiar object which is certainly not a star as commonly understood. It appears as a faintly luminous cloud of gas, spread out over a distance which is large compared with a star. Some of the gas is in extremely violent motion, and it seems likely that the generation of the radio signals must be connected in some way with this motion. Recently, two or three other similar objects have been located in the position of less intense radio stars, and there is also a good deal of speculation that this type of diffuse gaseous agglomeration may be responsible for many of the radio stars. There is no answer to the question as to the place of this type of object in the sequence of stellar evolution. The objects are so faint that they can only be seen by taking long exposures with the world's biggest telescope, and yet they generate powerful radio signals. Some attempt has been made to link them with very old supernovæ, of an age such that they are not in the epoch of recorded history. On the other hand, they may equally well be stars at the opposite end of creation, that is those which are in the very early stages of formation.

THE COLLISION OF NEBULÆ

Perhaps the most remarkable identification so far made is that of the second most intense radio source in the sky, which lies in the constellation of Cygnus. The early efforts to link up this radio source with a visible object, by inspecting the star maps, led to no result. There was nothing visible in the sky which seemed likely to be responsible for such a strong source of radio waves. About two years ago, however, as a result of the precision Cambridge measurements, referred to above, it again became possible for the American astronomers to train the Palomar telescope on the precise region of the sky which contained this radio source. Their plates yielded the usual large number of faint-stars and nebulae, but in the position of the radio source there was an object with an unusual appearance. It has been interpreted by Baade and Minkowski as showing two great nebulae in a state of collision. The distance of this celestial collision in Cygnus is enormous—a hundred million light years or just about the limit of the present observable universe. Why one result of such a collision should be the emission of powerful radio signals is quite unknown. The distance between the stars in a collision of two nebulae is so great, that actual interactions are unlikely, and it seems probable that the generation of the radio waves must take place somehow or other in the turmoil created by the gas and the dust, as these two nebulae pass through one another.

The establishment of the connection between this faint object at the limit of the observable universe, with the powerful source of radio emission in Cygnus, carries with it one of the most surprising implications in the whole of radio astronomy. The study of the radio records, coupled with the data about the distribution of these extragalactic nebulae in space, leads one to conclude that this type of celestial collision is by no means unique, and that it might even be a fairly common event. In the space around the Milky Way system, the distance between nebulae is of the order of a million light years. This is a fairly average

distance between nebulae in space and the chances of collision are negligible. On the other hand, in some regions of space the galaxies are far more closely packed in clusters, and in these we find, perhaps, a thousand galaxies separated by only thirty thousand light years. Although this distance is still very great, the galaxies themselves are moving with a speed of about fifteen hundred miles per second and a simple calculation indicates that the chances of a collision are considerable. Now in the case of the Cygnus collision we receive a powerful radio signal, although the two colliding nebulae are so distant that they are just at the limit of the universe observable by the big telescopes. If the galaxies were even further away, so that they could just not be identified by the telescopes, it would still be possible to detect their radio emission, even with the present radio telescopes. In fact, it is fairly easy to calculate that even with the sensitivities of present radio equipment, the colliding galaxies in Cygnus could be two or three times further away and still be measurable with the radio telescopes. Hence, if this type of celestial collision is as common as we now believe, even our present radio telescopes are capable of studying a volume of space which is, perhaps, five or ten times greater than the volume which is accessible to the greatest optical telescope in the world. This kind of possibility will almost certainly be greatly enhanced when the new radio telescopes now under construction come into operation.

THE SPECTRAL LINE EMISSION FROM THE NEUTRAL HYDROGEN GAS

The radio emissions from space are emitted over a wide range of wavelengths. Although the precise nature of the spectrum has not yet been established, it is well known that these radio sources can be detected over a range of wavelengths from a few centimetres to 15 or twenty metres. During the last year or so, however, a great deal of attention has been given to another type of radio emission from space, which is generated in the neutral hydrogen gas in the Milky Way on a wavelength of 21 centimetres. This is a spectral line, which is emitted when the spin of the electron in the ground state of a neutral hydrogen atom reverses. The possibility that this type of radio emission might occur was first suggested by van de Hulst in 1944 but it was not until 1951 that scientists in America, Australia and Holland succeeded in detecting and measuring this emission. The detection of this spectral line is in itself a remarkable achievement. The hydrogen clouds are tens of thousands of light years distant and contain only about one hydrogen atom per cubic centimetre. Moreover, this change of spin in the atom is only likely to happen once in about eleven million years. It seems, however, that the atoms in their random motions collide every fifty years, and in a collision there is a one in eight chance that this transition will occur.

The success in detecting this line in 1951 immediately opened up important new possibilities in radio astronomy and astronomy. The hydrogen clouds are in motion relative to the solar system and this 21 centimetre spectral line will, in consequence, show a doppler shift in its frequency. Using this technique the astronomers in Leiden have been able to study the detailed motions of the hydrogen clouds in the region of the Milky Way, which are obscured from the



FIGURE 1. A steerable radio telescope of diameter 30 feet in use at Jodrell Bank for the study of 21 centimetre emission from the interstellar hydrogen gas. The receiving dipole can be seen at the focus which lies in the plane of the aperture. This radio telescope is approximately one-eighth the size of the new telescope now under construction and shown in Figures 2 and 3.

view of the optical telescopes by the great dust clouds. Whereas a few years ago there was a good deal of speculation as to the exact structure of the Milky Way system, these uncertainties have been very largely removed and in a few years the Dutch astronomers have presented us with a most remarkably complete description of the spiral formation of the Milky Way system. The extension of this work to the extragalactic nebulae by the use of larger radio telescopes is eagerly awaited.

THE NEED FOR LARGE RADIO TELESCOPES

Now these studies of the radio emissions from space are carried out on a wavelength a million times longer than the wavelength of the light waves which are focused by the conventional optical telescopes. The radio waves are unaffected by cloud, fog or daylight and in this respect the radio astronomer has a marked advantage over the traditional methods of astronomical investigation. On the other hand, because of the long wavelength, it is extremely difficult to achieve any appreciable resolution. The beam width, or the angle of the cone in which the radiation is received, depends on the ratio of the wavelength to the diameter of the telescope. Thus, to achieve the same resolution as a very small optical telescope, the aerials of a radio telescope would have to extend for thousands of miles. The need for the maximum possible resolution in the radio work has been a dominant feature of the technical developments. A great deal has been achieved by special devices in which two similar aerial systems, spaced by several hundred yards, are connected to a common recording equipment. This type of radio telescope, known as an interferometer, has been intensively developed in Cambridge and Sydney, and it was with systems of this type that the original discovery of radio stars was made.

In an alternative approach, the physical size of the aerial system is increased. There are now several steerable radio telescopes of small size in existence and the largest is believed to be the transit radio telescope at Jodrell Bank, which has an aperture of 220 feet, but this is fixed to the earth and only a small part of the heavens can be explored. Experience with this instrument soon demonstrated that a completely steerable radio telescope of this order of size was a prerequisite for the further exploration of space by the radio method. The engineering difficulties and expense of such an undertaking are formidable. Nevertheless, the results to be anticipated were such as to enlist the sympathetic interest of many prominent scientists, when the idea was first put forward in 1949.

In conventional astronomical investigations, the telescope has been the crucial instrument for the exploration of space. Successive increases in size have led to more light-gathering power and greater resolution and although the improvements in auxiliary instruments, such as photographic plates and spectroscopes, have been very important, nevertheless the great advances in observational astronomy have come primarily from larger and larger telescopes. The situation in radio observations is very similar. Whereas large optical telescopes are required to improve the light-gathering power and the resolution, large radio telescopes are required in order to be able to pick up faint signals at greater distances from

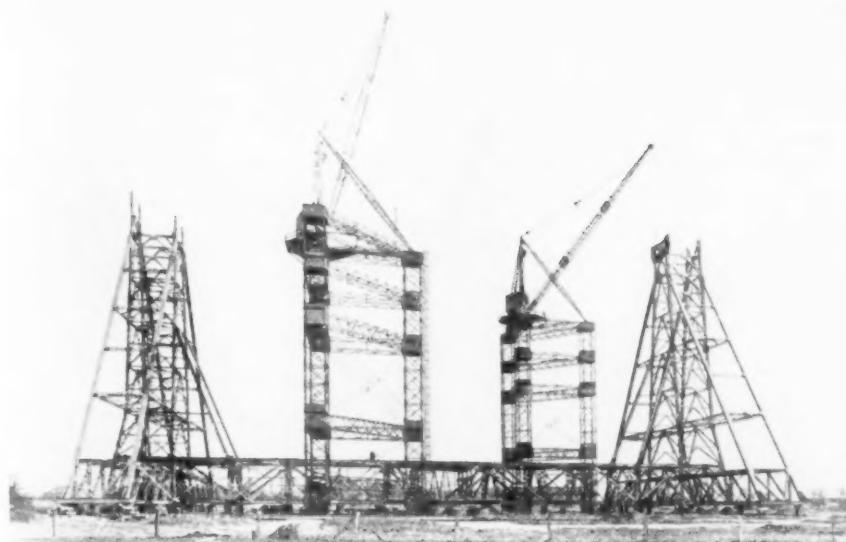


FIGURE 2. *A general view of the site of the 250-foot aperture steerable radio telescope as it appeared in the spring of 1955. The steel towers which are to support the bowl can be seen in process of erection by the two cranes which will be dismantled eventually. The topmost girder on the right-hand tower will carry part of the trunnion-bearing mechanism and is at a height of about 180 feet above ground level. (The engineering design and the supervision of the erection of the telescope is the responsibility of Messrs. Husband & Co., Consulting Engineers of Sheffield.)*

the earth, as well as for greater resolution. The Department of Scientific and Industrial Research and the Nuffield Foundation gave financial backing to this proposal for a large steerable radio telescope. This telescope, which is now being built in Cheshire, at the Jodrell Bank Experimental Station of the University of Manchester, will have a paraboloidal reflector of steel sheet with an aperture of 250 feet. This moving bowl will weigh 500 tons and by supporting it on steel towers rising 180 feet above the ground, it will be possible to direct it to any part of the sky. The accompanying photographs give some idea of the final appearance of this telescope, and of the present stage in its construction. The foundations contain thousands of tons of reinforced concrete to hold the 17-foot gauge double railway track on which the telescope rotates. The steel towers run on 12 bogies driven by electric motors, and the racks for the elevation movement have been taken from the dismantled battleship Royal Sovereign. There are grounds for hope that preliminary tests with this telescope in a fixed position may be made in the autumn of 1955 and that the telescope will be under full powered control in 1956.

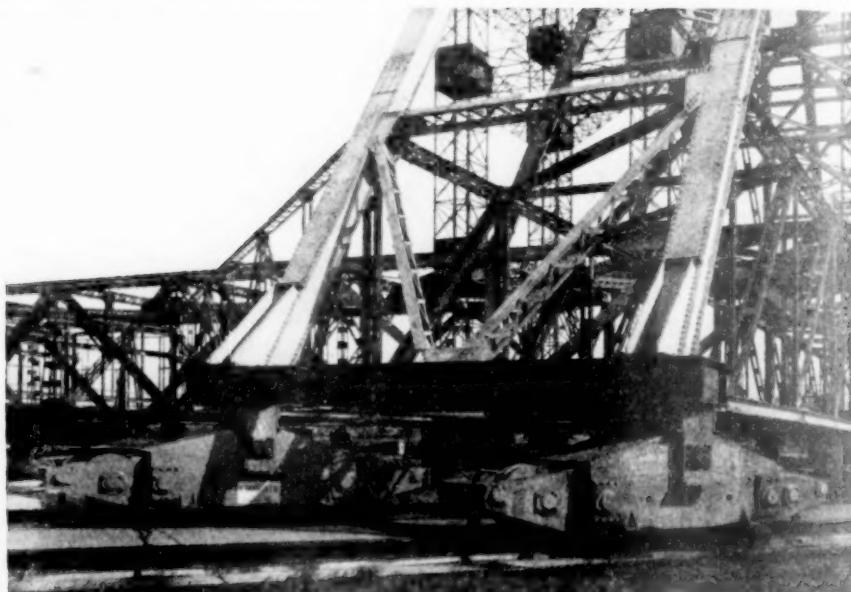


FIGURE 3. Whereas the 30-foot radio telescope illustrated in Figure 1 is rotated by an electric motor driving through gear wheels on a central pivot, the 250-foot telescope rotates on 12 bogies running on a 350-foot diameter 17-foot gauge double railway track. Two of the bogies and a part of the track can be seen in this photograph. The central pivot appears on the extreme left of the photograph underneath the cross girder

The beamwidth of this telescope will be about one degree when used on a wavelength of one metre and its power gain will be over sixteen thousand. On the wavelength of the spectral line at 21 centimetres, its beamwidth will be a few minutes of arc only. The great discrimination and the power gain will be used to elucidate the nature of the radio sources and to plot detailed maps of the sky, particularly in those regions which are obscured by the interstellar dust. In the field of the 21 centimetre emission great importance is attached to the extension of these studies to the extragalactic nebulae. At the moment, it seems likely that the fascination and importance of these problems associated with the radio emissions from space will occupy nearly the whole time of the telescope for the first few years of its working life. On the other hand it has always been intended that the radio telescope should be used in all aspects of radio astronomy, including those in which radio waves are first transmitted from the earth

THE DETECTION OF METEORS BY RADIO

Prominent amongst such uses will be the study of meteors or shooting stars. Although eight thousand million of these fragments of stone and iron bombard the earth's atmosphere every day, their investigation has always been peculiarly

difficult. The streak of light created in the high atmosphere as the meteor burns away is so transient, that the accurate measurement of the velocity and direction by visual means has been almost impossible. The development of photographic techniques has provided the necessary accuracy, but unfortunately the interesting events are often obscured by cloud or bright moonlight. However, a part of the energy of the meteor is used in ionizing the air through which it passes, and the resultant thin column of electrons scatter back to earth radio waves which are sent out on an appropriate wavelength. In the last few years, this radio echo technique for the study of meteors has been brought to a high state of perfection. Methods for the accurate determination of the velocity and direction have been developed, and now at Jodrell Bank there exists an apparatus which can measure accurately the individual orbits of several hundred meteors a day.

A great advantage of the radio echo technique is that the study of meteors can be carried out without hindrance by cloud or daylight. The discovery that great streams of meteors are active in the summer daytime must be considered amongst one of the most dramatic results of this new technique. These daytime meteor streams move around the sun in orbits of only a few years period. One stream is almost certainly moving in the orbit of Encke's Comet, but for the remainder no relations with other bodies in the solar system have yet been established. It is certain that several of the major meteor streams are in some way associated with comets, on the other hand the origin of the sporadic meteors remains an enigma. Some years ago there was a prominent body of astronomical opinion which believed that these sporadic meteors were of interstellar origin. The radio echo work has proved beyond doubt that they are localized in the solar system and actually move in very short period orbits around the sun.

The fundamental interest in this aspect of the work is cosmological—where do these meteors have their origin; are they the primeval matter left over from the formation of the solar system, or are they the result of some subsequent cometary or planetary disintegration? On the other hand, the radio investigation of the meteors can be used to measure the physical and meteorological conditions in the atmosphere fifty to 120 kilometres above the earth's surface. Pressures, temperature, scale height, winds, diffusion coefficients and many other topics come within the province of these investigations. It is obvious that the interests in this aspect of radio astronomy extend far beyond the study of meteors as such, into the ramifications of meteorology, ballistics and high-speed flight at great altitudes. The actual atomic processes involved in the evaporation of the meteor, and the mechanism by which the radio waves are scattered, open up further wide avenues of research in physics.

THE STUDY OF THE MOON AND THE PLANETS

The detection of meteors is possible because they produce an ion trail which is an efficient scatterer of radio waves. In the case of the moon, nature provides no such assistance, and contemporary techniques have to be strained almost to the limit, in order to transmit a pulse of radio waves and record it $2\frac{1}{2}$ seconds

later when it has been scattered back from the lunar surface. The radio waves, in this case, make two complete traverses of the ionosphere, and most interesting results have been obtained regarding the rotation of the plane of polarization of the radio wave. The new telescope with its high power gain will greatly facilitate these lunar studies. The spectacular task of obtaining radio echoes from the planets will also be brought within the scope of modern techniques. In this case, enormous dividends will undoubtedly be reaped, including the determination of the rotation period of Venus and a more accurate measurement of the solar parallax.

SOLAR-TERRESTRIAL RELATIONSHIPS AND THE AURORA BOREALIS

Finally, the telescope will be an invaluable asset in the investigation of many aspects of solar-terrestrial relationships. The origin of the sunspots is not yet understood, but the phenomena which follow their appearance on the solar surface often have dramatic consequences so far as the earth's radio communications are concerned. The sun itself emits radio waves. These appear to originate in the corona, but when a spot appears on the surface much more intense radio waves are emitted, and these are known to originate in the region of the spot itself. Occasionally when the spot activity is considerable a solar flare forms in the region of a group of spots. The flare itself is generally only of a few minutes duration, but it initiates a complex sequence of events which are felt on the earth for days afterwards. It is believed that these events result, first, from the emission of intense ultra-violet light, and, secondly, from the ejection of great streams of hydrogenous material. The effect of the former is evident within the eight minutes which light takes to travel from the sun to the earth, but the corpuscular streams travel more slowly and take about 24 hours to traverse the 93 million miles of space separating us from the sun.

The intense flash of ultra-violet light creates a new layer of ionization at a height of about eighty kilometres above the earth. Normally transoceanic radio signals penetrate this region and are reflected from either the E or F region of the ionosphere. When the eighty kilometre region becomes ionized the radio waves are absorbed and there is a sudden and complete cessation of long distance radio communication. Simultaneously, intense bursts of radio emission from the flare are received, and there is a sudden disturbance in the earth's magnetic field. Fortunately, the flare is of short duration and the ionized layer at eighty kilometres quickly disappears, with the result that normal communications are generally restored within about thirty minutes. About a day later, however, the earth suffers the impact of the more slowly travelling corpuscular streams. These cause serious upheavals in the F region of the ionosphere. Although there is no sudden cessation of signals as in the former case, nevertheless the fading and distortion is such as to interfere very seriously with long distance radio communications. In this case, the trouble may manifest itself for several days. At the same time there are often brilliant displays of the aurora borealis.

Although it is possible to give a general phenomenological description of these events, the detailed processes are not well understood. In fact, there is still

dispute as to the reality of the corpuscular streams. The new radio telescope will fulfil its part in these investigations, particularly in the study of the radio emissions from the solar flares and sunspots, and in the study of the aurora borealis by the radio echo technique. Here again, the ionized material in the aurora forms an efficient scatterer of radio waves, which enables aurorae to be recorded and studied under cloudy conditions, and also in daylight. A direct attempt will also be made to detect the corpuscular streams by the radio echo technique, but in this case one cannot be sanguine as to the result.

CONCLUSION

British astronomy achieved distinction in the eighteenth and nineteenth centuries, when the Earl of Rosse and Sir William Herschel pioneered the construction of large telescopes. Unfortunately the country's leadership was doomed to capitulation to those living in a more favourable climate, and in this century the world has looked to the American continent for the startling advances in our knowledge of the universe. Now, by a strange twist of fate, the devices of war have been transformed into a revolutionary method for the exploration of space, independent of cloud or fog. In the study of the universe and nearby space, with its important ramifications in more practical matters, Britain can once more compete without handicap. The greatest radio telescope in the world will soon be operating within these shores, and scientists everywhere now with great confidence watch it rise to completion.

DISCUSSION

MR. L. W. CLARKE: Would Professor Lovell tell us if it will ever be possible to examine such a thing as, for instance, the corona of the sun, as distinct from the sun itself, by means of radio astronomy? Is the instrument sensitive enough to be directed to an area which is relatively small, such as the corona of the sun would be in comparison with the whole sky canopy?

THE LECTURER: Yes. A very great deal of information has already been gained about the solar corona from these studies in radio activity. In fact, the radio emission one picks up from the sun on a day like this, for example, when there are no spots on it, is now well known to originate in the corona. Many scientific papers have been published on this by our colleagues in Sydney, and by Ryle and his colleagues in Cambridge, who have made a very special study of the nature of the emission from the corona and its distribution. The effective temperature as measured from the solar radio emissions is now well established. The equivalent black body temperature on a wavelength of a metre is of the order of a million degrees and is somewhat less as the wavelength decreases. Another most interesting result is that, as far as the so-called radio sun is concerned, the corona extends for very much greater distances than can be seen optically. In other words, even when the solar corona is invisible the electron density is sufficient to guarantee radio waves by which it can be investigated. In fact, on a wavelength of about eight metres, the radio sun appears to be about two or three times the diameter it does to the eye.

MR. JOHN CLARRICOATS, O.B.E. (General Secretary, Radio Society of Great Britain): The radio amateurs of this country, equipped as they are with good receivers and filled with tireless enthusiasm, would be happy indeed to co-operate to the best of their ability in the great work that is being done at Jodrell Bank.

Professor Lovell's statement that there was apparently yesterday afternoon a 'flare-up' in the aurora, is intensely interesting from the amateur point of view. Does Professor Lovell think it would be possible, at a later date, for the B.B.C. or some other authority to give an indication each night, in their weather bulletins, as to the possibility of radio conditions during the next 24 hours?

There are in this country about 20,000 radio amateurs, and of that number many are interested in very high frequency investigation. Dr. Smith Rose, who is here, has some knowledge of the work that the amateurs have done and are doing. One difficulty they experience all the time is that of having no prior notice of when propagation conditions are likely to be good or very good. I believe that Jodrell Bank may be in a position ultimately, perhaps in a year or two, to help all those enthusiastic workers who would like to co-operate with Professor Lovell in the work that he is doing and in the work being carried out by other Government departments.

THE LECTURER: We always value the co-operation with radio amateurs in this country and throughout the world. It is very difficult to give a concise answer to the questions raised about the possibility of easy warning of disturbed conditions and I would prefer to go into conference with Dr. Smith Rose on the matter. The International Geophysical Year is approaching, and the co-operation of as many amateur observers as possible will be needed during that time, and I think we might greatly value this, especially in the case of the aurora on which we are particularly anxious to get observations. I would also suggest that apart from our helping the amateurs they may well be able to provide us with very valuable information, particularly during the international years, 1956, 1957 and 1958, but I think this does need detailed discussion with Dr. Smith Rose.

DR. G. S. BROSAN: I should like to know roughly what sort of frequency distribution has been observed, and whether there has been any frequency drift from a given source?

THE LECTURER: I take it that you mean frequency distribution of intensity of the radio stars. Unfortunately, the evidence is not yet very good. It is one of the early experiments we have planned with the new telescope, but the things we do know are that in the case of the Taurus (the Crab Nebula), the flux does not appear to change very much with the frequency. On the other hand, in the case of the Cygnus and Cassiopeia radio stars, the flux certainly falls off as the wavelength decreases down to the shortest wavelength that has so far been measured, about ten centimetres or so. At the longer wavelengths the flux is still missing up to about 13 metres where the ionosphere makes further extension difficult.

Thus the general answer is that, apart from the spectral line, the emissions in some cases appear to be independent of frequency, and in others appear to fall off as the wavelength decreases.

MR. H. V. GRIFFITHS: I was very interested to hear that the radio telescope had detected an auroral display yesterday afternoon, because it was followed immediately by an ionospheric radio disturbance that was particularly evident in the late evening.

It may not generally be known that the B.B.C. makes announcements concerning ionospheric disturbances that affect short-wave reception, and these announcements go out in the B.B.C. General Overseas Services, and in some of the foreign language services; but I think perhaps the representative of the Radio Society of Great Britain, in referring to amateur interest in long-distance very high frequency transmissions, had in mind some possible B.B.C. announcement about tropospheric reception conditions, which would be a different matter.

With regard to meteor whistles, the first radio phenomena to be observed, indicating the arrival of meteors, were these heterodyne whistles that can often be heard in

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receiving short-wave broadcasts. These peculiar little grunting noises are quite commonly audible in the short-wave bands when meteors are passing through the upper atmosphere.

THE LECTURER: I do agree about the whistles. We use that kind of technique for measuring with precision the velocities at which the meteors come into the atmosphere—not from actual recordings of the pitch, but from the study of the diffraction patterns photographed on a cathode ray tube.

MR. W. BAKER: I should like to ask Professor Lovell if it is possible to detect the deflection of radio waves passing close to the sun in the same way as was observed in the case of light from a star during the total eclipse of the 1920's, thus confirming Professor Einstein's theory?

THE LECTURER: I think not. Our instruments at the moment are far too crude to make such measurements. The Cambridge team have studied the refraction of rays from one of the distant radio sources as they pass through the solar corona. It may be possible to carry out an experiment with the new radio telescope which has more bearing on the question. That is the study of the 'red shift' of the 21 centimetre radio emission from the extragalactic nebulae. The result of such a measurement is bound to have great relevance to the theories of the expanding universe.

MR. R. H. TUCKER: Can Professor Lovell give positional astronomy any help in determining the distances of the moon from the earth, the sun from the earth, and later on perhaps the planets from the earth, so that the results may be of some value in determination of the scale of the solar system?

THE LECTURER: Yes, with the new radio telescope, if we are allowed to build the very complex and difficult equipment which will be necessary for us to get an echo from the planets. It is among the experiments which we should very much like to make. As you have suggested, it would enable one to refine the measurement of the solar parallax by something like a factor of ten over the best value known at present. It would also enable one to settle the problem of the rotation of Venus, but it is an extremely difficult problem, and one would have to strain contemporary technique to the limit. In so far as we have probably strained engineering practice to the utmost to build the big telescope, so one would have to strain valve and electronic techniques to do this, and it would be an extremely expensive business.

DR. E. R. R. HOLMBERG: Has Professor Lovell detected any polarization?

THE LECTURER: Almost none. It is very surprising. Some time ago, Ryle concluded that the emission from the Cygnus and Cassiopeia sources showed no polarization effect greater than five per cent. Ambartsumian, the Russian astronomer, came to us last autumn, and said that in the Crimea they had detected a polarization of 15 per cent in the light from the Crab Nebula. We then carried out an experiment to test if the radio emission from the Crab Nebula was polarized, but as in the case of the other sources no polarization has been measured.

THE CHAIRMAN: After a lecture such as Professor Lovell has given us, I am sure that none of you would like to leave this historic lecture hall without expressing your thanks, not only for the information and interest of the lecture itself, but for the way in which he made the subject matter intelligible and understandable by all.

The radio astronomers have opened up a new mine of knowledge. Professor Lovell is one of the leading diggers, and out of the mine is coming not only a new map—a more complete map of the universe but, important as that may be, the possibility also of learning a lot more of great importance about the fundamental nature of things.

It is a great privilege for me, as it would be for anyone, to express on your behalf a most hearty vote of thanks and appreciation to Professor Lovell for this lecture.

The vote of thanks to the Lecturer was carried with acclamation.

SIR LIONEL THOMPSON, C.B.E.: I am sure that you would not like to leave before expressing our gratitude to our chairman, Sir Ben Lockspeiser, for many things. First and foremost, for presiding so genially and so learnedly over our proceedings this afternoon, and secondly for the very great debt we owe to him from the Royal Society of Arts, as evidenced quite recently by the lecture he gave in connection with the Bicentenary. We must also congratulate him on the development of the idea which he had the vision to foster and support in the face, no doubt, of critical financial observations on the part of those who represented the taxpayers and who had, quite properly and naturally, some reluctance to part with their money. I feel that I speak for you all when I say it is with deep gratitude for these things that I ask you to join with me in giving Sir Ben Lockspeiser a hearty vote of thanks for his services.

The vote of thanks to the Chairman was carried with acclamation, and the meeting then ended.

G E N E R A L N O T E S

PAINTINGS BY SINGAPORE ARTISTS

One of the problems of any art society to-day is to be quite fair to the conflicting art 'movements', that are such notable features of contemporary art. That the Singapore Art Society manages to do this successfully is evidenced by the seven representative artists, whose work the society has sponsored, in a special exhibition at the Imperial Institute Gallery. Altogether there are over a hundred exhibits in a show, that would hold its own with almost anything, on the same lines, that London could produce. Out of the seven exhibitors, five were trained in the traditional Chinese style. Of the remaining two, Suri Bin Mohyani, who is also an author, shows three effective river scenes; and, though Ho Hok Hoe is the youngest member of the society, he is its president and dominates the exhibition. It is true to say that the annual shows of the society are now regarded as a major event in Singapore. It is to the credit of the founders and organizers that the society, which came into existence only six years ago, and which has provided asylum for many distinguished Chinese artists, should now occupy a prominent place in the life of the colony.

The President, who is an A.R.I.B.A., is clearly a man of strong character. He explains the four 'moods', which underlie the traditional approach of the Chinese artist, as the 'Divine Mood', the 'Superior Mood', the 'Ingenious Mood' and the 'Capacious Mood', which would seem to lead the initial conception through stages of development into complete fulfilment of expression. Whether Mr. Ho consciously follows these 'moods' in the creation of his own works (which have kinship with both East and West) could not be assessed by an outsider. The artist is certainly a very gifted man. His *Winslow Oak* might have been painted by a member of the Royal Water-Colour Society; his Chinese painting *Trio* with its three cocks simply brushed into life and alertness by their red combs, and a dozen travel sketches of England and Ireland, are all the work of a man who reveals both the results of considerable training and the spontaneous gifts of an instinctive artist.

It is just as well to recognize, however, that there are people who, having become worshippers of Chinese scroll paintings, will not look at anything else. Such people will miss a great deal in an exhibition of this kind, though it does make their limited taste readily understandable. A walk round the far end of the gallery may well unnerve the lover of our ordinary easel paintings. After all, there is little more to be said about *Fish* than that they have structure and swiftness (since, under water,

their colour is necessarily muted); and Chen Wen Si co-ordinates these two qualities in rhythmical creations; and his alert *Winter Birds* standing by a thick tree-trunk are instantaneous blobs of significant and decorative life. In his oils, however, the painter shows us a *Storm* that has something of the angular forms of Cézanne, and the recessional poetry of Ivon Hitchens. The painter, who was a student of the Sin Hua Art Academy of Shanghai, is one of the leading Chinese artists. He recently painted a portrait in oils of Sir John Nichol, the present Governor of Singapore. Nearby, it is easy to appreciate the sheer gracefulness of Cheong Soo Pieng, whose women in *Bathing* are charmingly portrayed near a waterfall, made swiftly adequate for ablutions in six romantic lines.

The scrolls, however, do call the visitor repeatedly. The most characteristic are the calligraphic *Plum Blossom* (with the long perpendicular Chinese writing at the side) and the *Bamboo* with damp blots for leaves—and a heavy pressure on the brush to add to the weight of the stems. Both are by Lim Hak Tai, who was one of the founders of the Amoy Academy of Fine Arts, and is now Principal of the Nanyang Academy at Singapore.

Just as some of our own western artists may have derived their own style (directly or indirectly) from earlier Chinese painting, so it is possible to see hints of the return journey in two water-colours by Tay Wee Koa. The painter must have followed his own country's tradition in scroll paintings certainly, but there seems to be a hint of the damp fluency of Sargent. At this stage, however, it becomes a problem of origin, and who is derived from whom. Anyway, it is an enchanting exhibition.

G. S. SANDILANDS

PUBLIC HEALTH COMPETITIONS

The Council of the Royal Society for the Promotion of Health (formerly Royal Sanitary Institute) announces that prizes ranging from £100 to 20 guineas, are offered this year in open essay competitions on the following subjects: 'The thermal insulation of dwellings and the design of water supply and waste drainage systems to achieve freedom from frost hazard'; 'The design and fitting of sanitary appliances to reduce noise and its transmission through buildings'; 'The problem of engine exhaust fumes from road vehicles'; 'How the health visitor can help the family towards its full development', and 'The day-time care of the "under-five" whose mother is at work'. The prize for the first competition is to be used for a three-week study tour in Europe. The closing date for entries is 31st December, 1955. Full particulars can be obtained from the Secretary, Royal Society for the Promotion of Health, 90, Buckingham Palace Road, S.W.1.

NOTES ON BOOKS

PROFITABLE EXPORT MARKETING. By Martin Madden. Newman Neame Ltd. 15s

The slogan 'export or die' has gone the way of much repetitive exhortation and worn thin with the years. Yet nobody has recorded the number of firms which have died, nearly died, or spoilt the market for others by exporting, firms which in fact should never have exported at all, either because they had not the means or did not know how. Yet in spite of the boredom of slogans the need for increasing our exports remains as urgent as ever, and although our performance improves steadily, it is not nearly good enough. The post-war seller's market led to complacency in export marketing in a world which was hungry for goods. The more recent appearance of a buyer's market, the healthy stimulus of foreign competition and periodic movements of the terms of trade to our disadvantage have put firms on their mettle to export more and more efficiently. There are, however, still many firms with full order books enjoying a seller's market and there is still a corresponding lack of forward thinking about export markets.

Mr. Maddan's book is a very useful handbook for the exporter in the present situation. As a former member of the staff of B.E.T.R.O., one might have expected some wistfulness and nostalgia. There is, however, a healthy absence of any such retrospective approach and while giving full credit to B.E.T.R.O. and his former colleagues, and getting full support in an introduction from Mr. Roger Falk, its former Director General and the present chairman of B.E.T.R.O. (1952) Ltd., the author attacks his subject with forward-looking gusto. As the first book to appear on the subject of overseas market research, it is essentially practical and readable, appealing not only to the whole hierarchy of practical businessmen from chairmen, managing directors and export managers down to the salesman in the field, but also to teachers and pupils concerned in business training. B.E.T.R.O.'s demise was in some measure due to the coincidence of its life with the seller's market, which made many consider its activities as superfluous, and this book should correspondingly be assured of success, born as it is under a less favourable conjunction of bodies in the economic heavens.

While Mr. Maddan's book is concerned with market or marketing research, he is wise to have avoided any allusion to the fact in the main title, because many potential readers would be deterred from reading it, as they often rightly associate market research with a new form of economic witchcraft, or mumbo jumbo, indulged in at the expense of the practical business man by a freemasonry of theoretical economists, smart advertising agents, business consultants, and a few innocent enthusiasts with a secret, illiterate jargon of their own. The author is not writing for the specialist, his book is accessible to anyone, and with his practical and frankly profit-minded attitude, that it pays to look before you leap into export, he exposes most of the mystery surrounding the art in his survey of methods and techniques. He includes a useful bibliography for the reader who wishes to pursue the subject further and provides a glossary of terms which is helpful, though it will not reconcile the purist to the misuse of such words as 'universe' for the equivalent of 'microcosm' or 'random' and 'randomization', for what is in fact almost the exact opposite in the form of deliberate selection. In addition to a practical check list of marketing information, there is an appendix of world information and research sources compiled by N. Peter Vigart, which is a handy reference catalogue.

The book is exhaustive in describing the extent and limitations of the various means available for finding out all the necessary facts so that, provided they are adequately interpreted, the minimum margin is left to chance. It is well illustrated with typical case histories, ranging from dentures to heavy machinery. It covers the essential information required and the means of getting it, whether at home or abroad; the proper use of personal visits to the market; selection of and co-operation with sales agents; surveys through retailers, wholesalers, consumers and users; preliminary market studies; techniques such as product and package testing, test marketing, retail shop audits, consumer panels, brand barometers; surveys at exhibitions, and finally the question of the cost of employing experts at home and abroad.

It is altogether a stimulating and useful book. It would, however, be presumptuous to assume that the author is in any way attempting to give the whole answer. He is attempting to give one of the answers to the problem of profitable export marketing, by encouraging the enquiring mind and seeing that the exporter at least knows what questions to ask and how and where to ask them, in the hope that if a fair proportion can be answered, appropriate action can follow, which will ensure a greater probability of success than the old game of hit and miss. The book may also be a salutary warning not to enter the export field unless there is a fair chance of a firm being able to devote some serious attention to these questions. The extent to which satisfactory answers can be found will vary according to the accessibility of the particular market and the degree of industrial and commercial civilization in the country concerned. It

would be foolish to assume that the almost excessive facilities available in the United States could in any way be matched by Bulgaria or Indonesia. It would also be impracticable and too costly for most firms to indulge in more than a moderate dose of the techniques available, and it is up to them, with the help of experts, to lay their own plans for research and marketing in the most appropriate manner for the product concerned. The book is a handy guide to the whole subject. Its main shortcomings are a few minor mistakes in the appendix, the persistent printing of 'eg' instead of 'e.g.' and the possibly unavoidable use of market research jargon, which occasionally arrests the flow of an otherwise very readable text, while the funny side of the subject, and after all there is much fun to be had in the export game, might have been treated with greater levity.

P. F. D. TENNANT

DECORATIVE ART, 1954-55. Edited by Rathbone Holme & Kathleen M. Frost. *The Studio*, 1954. 30s

Modern design, particularly in room furnishings, has recently been belaboured from left and right, so to speak. A furniture trade unionist writing in a trade journal has won favour with many employers in his industry for a defence of the commercial bread and butter of his trade; two writers in *The Sunday Times* have criticized modern furnishings for their starkness and their inhumanity. This sort of pincer movement could be very damaging to the tender reputation of modern design for it is based on a dangerous combination of fact and fiction; the fact that modern design now has enough following to make it commercially interesting, and the fiction that it is simply an intellectual plaything that is somehow being foisted onto an innocent and unwilling public.

The existence of an official body concerned with standards of design no doubt lends points to the word 'foist', for those who recognize no need for improvement are bound to look upon any organized effort to improve standards as an unwarrantable interference with private enterprise and personal choice. But politics or prejudice apart, the situation is serious, for the new ideas are by no means so firmly rooted that they can passively weather such a combination of ill-winds.

There is so much rubbish being manufactured to-day under the guise of 'contemporary design', so many half-baked clichés being commercially exploited, that discriminating people may almost be excused for damning the whole modern movement. Equally the layman who has grown used to mass-produced vulgarity in a robuster idiom will react against mean, tradey interpretations of ideas that even in the originals he might have found strange and unfamiliar. He will take courage from the thought that people who know better also share his views.

But what is the alternative? Do we put the clock back? Do we fish out old hand-made models and try to make them by machine? Do we leave the field wide open for a return to the pseudo history and false glamour of the repro-Jaco and modernistic cocktail trade? Or do we try again, talking this time less about contemporary design and more about good design, less about idioms and more about quality?

If we choose the second course, we would do well to study the pages of *Decorative Art*, the *Studio Year Book of Furnishing and Decoration*, for here is collected a good cross section of recent designs from many countries and from many industries. It is as conscientious an annual anthology of new work as is produced in this country. It shows at least that the modern movement is broadly based internationally but also that national tastes vary; that Americans favour straight lines and contrasting weights in their furniture; that the Scandinavians prefer flow and movement; that the French lean towards custom-made furnishings for the interior decorator rather than towards pieces produced in quantity for the shops; that the British are still in the vanguard for textiles and flat patterns, but that we are still bringing up the rear in silver and pots for the table.

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Yet it is on the whole an encouraging picture, full of variety and colour. If anything can shake the *idée fixe* that modern design is synonymous with boring austerity or repetitive uniformity the 1954-55 edition of Decorative Art should do it.

PAUL REILLY

SHORT NOTES ON OTHER BOOKS

HISTORY OF THE NATIONAL ACADEMY OF DESIGN, 1825-1953. By Eliot Clark. O.U.P., 1954. 52s

This is the story of the oldest art institution in the United States governed and controlled by artists. The History describes the founding and subsequent organization of the Academy, and includes chapters on the development of American art, and of architecture, sculpture, engraving and etching from 1825 to the present day. There are 13 illustrations.

MEMLINC. By Charles Johnson; TOULOUSE-LAUTREC. By R. H. Wilenski; DUFY. By Pierre Courthion. Faber, 1955. Each 9s 6d

These three books are now added to the Faber Gallery series. Each book contains an introduction, and ten colour plates with accompanying notes. They continue the high standard set by the earlier publications.

RAIN IN MY HEART. Forty Poems by Adi K. Sett. The Fortune Press, 1954. 6s

This is a revised edition of the collection of poems first published in 1948. It has been edited by Fredoon Kabraji, and contains a foreword by Sir Eugen Millington-Drake. The poet, who is Indian, writes in English.

FROM THE JOURNAL OF 1855

VOLUME II. 3rd August, 1855

THE SOCIETY'S VISIT TO THE INTERNATIONAL EXHIBITION IN PARIS

From a letter by Percy Sadler, one of the Committee of the Hackney Institution.

Sir,—As the Council of the Society of Arts are about making arrangements for a visit to Paris, I take the liberty of offering a few remarks, which I hope will not be deemed impertinent. . . .

Your correspondent, Mr. Reid, recommends private lodgings in preference to hotels, and he is right in so doing, because at the hotels they expect you to take your meals, which economists will find rather an expensive mode of living. Private rooms are to be found in what are called *Maisons Meublés*, at about two francs a day, in respectable houses, on the third and fourth floors; they charge, however 10 sous, or half a franc per diem, for service (servants), to whom you are not expected to give anything when you leave.

Foreigners ought to remark a distinction between *Maisons Meublés* and *Maisons Garnies*; the latter are certainly the more economical, but not the more respectable of the two classes; they abound in the Pays Latin, or Quartier Latin, or Student's Quarter; but although you may there be treading the most classic ground of Paris, it would be too great a stretch of toleration to recommend it as the most holy, any more than the purlieus of the Palais Royal. . . .

With respect to the Exhibition, the arrangements are admirable. I have visited it several times within the last fortnight, both on the cheap and on the dear days, and have remarked with pleasure that the only difference observable between the four-sous and the five-franc days was, in the costliness (not cleanliness) of toilette. Decorum prevailed as much on one day as on the others.

